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FLOWERING BEHAVIORS OF TAIWAN AVOCADO CULTIVARS

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SUMMARY

The flowering behaviors of 9 main avocado cultivars in Taiwan were observed for three years. Our observation included 6 Taiwan local cultivars- 'CAES 1', 'CAES 2', 'CAES 3', 'CAES 4', 'Hung-Shin-Shi-Yeh', '79-6-5-3', and three foreign cultivars- 'Halemana', 'Hall', 'Choquette'. Only 'CAES 1', 'CAES2' and 'Hall' belong to B type, and the others belong to A type. All of the cultivars flowering from December to April were divided into early, middle, and late flowering groups. The flowering period of 'CAES 4', which is the earliest flowering cultivar, begins at early December and ends at late March. 'CAES 3' is later than 'CAES 4', which blooms from mid-December to early April. '79-6-5-3', 'Halemana' and 'CAES 1', which belong to the middle flowering group, bloom from late January to mid-March, late January to early April, and early February to late March respectively. The flowering periods of the late flowering cultivars, which include 'Hall', 'CAES 2', 'Hung Shin Shi Yeh' and 'Choquette', are from late February to mid-April, early March to early April, early March to early April, and early March to mid-April respectively. The full bloom period of 9 cultivars lasts about 1 to 2 month. The effect of low night temperature (which means the minimum night temperature is below 18º, especially lower than 15º) on the flowering cycles of 'CAES 3', 'CAES 4', 'Hall' and 'Choquette' was also observed. The flowering of both female and male flower stages was delayed , so was the anther dehiscent time. Meanwhile, 10% to 60% stigma of these four cultivars remained in white color during male flower stage. It seems reasonable to conclude that Taiwan's avocado might have high selfing rate (close pollination and self pollination) and it is possible to plant only one type of cultivars in the same area.

Key Words: flowering type, temperature, pollinated combination, Taiwan

INTRODUCTION

Flowering type and pollinate combination of avocado are not so concerned by avocado grower in Taiwan for at least three reason that are small orchard, too many cultivars were planted in one orchard and the climate. Almost all of Taiwan avocado farmer are small holder, mean area of the orchard is about one hectare. The farmer didn't care about pollination trees; even they always plant the cultivars with different flower date and same flowering type, because the pollen could provide from their neighbours. Meanwhile, most of Taiwan farmers like planted a lot of cultivars in their orchard, although their orchard is quite small. So they didn't worry about flower type and pollination tree. Moreover, high relative humidity and frequently low night temperature during Taiwan avocado flowering season, which following by Davenport (1989), Davenport et al. (1994), Loupassaki, et al. (1994), Papademetriou (1976), Sedgley (1977), Sedgley and Annells (1981) and Sedgley and Grant (1983) will cause high possibility of cross pollination, cause people neglected this important characteristics.

Taiwan avocado was introduced in Japanese occupied period, but was destroyed in the end of World War II without well prepare extension to the farmer. Fortunately, there still released a lot of seedling, some of them were selected as the local varieties, and were the main avocado cultivars in Taiwan now. This research was investigated flowering type and flowering season of main avocado cultivars in Taiwan, and the influences of temperature on flowering behaviours.

MATERIAL AND METHODS

1. Flowering behaviours of 9 Taiwan avocado main cultivars

Nine cultivars, which were 'CAES 1', 'CAES 2', 'CAES 3', 'CAES 4', 'Halemana', 'Hall', 'Choquette', 'Hung Shin Shi Yeh', '79-6-5-3', were used to observed flowering behaviours from 2000 to 2002. All of the tree were planted in the avocado variety garden of Taiwan Agriculture Research Institute, Chiayi Substation (NL. 23°29'10", EL. 120°27'15"). Inflorecsence and flower development were observed once for two weeks. Inflorecsences development stage was decided following by Salazar-Garcia et al.(1998). The flowering condition of a single tree was decided by the average of most of the bud.

2. Effect of temperature on flowering cycle of avocado

'CASE 3', 'CASE 4', 'Choquette' and 'Hall', which were planted in the avocado variety garden of Taiwan Agriculture Research Institute, Chiayi Substation (NL. 23°29'10", EL. 120°27'15"), were used to observed the changes of flowering cycle under low temperature during 2000 to 2002. At least 40 flowers were tagged in each cultivars in the morning during the cold current arrived Taiwan. The tagged flowers were observed once an hour from 8 a.m. to 6 p.m. Female and male flowering stage and the dehiscent time of anther was recorded, especially the overlape of female and male flower opening. Small flower flowering was devided into 5 stage, according to the angle of petal and pistil, which were 15, 25, 45 and 90 degrees for 1 to 4 dstage and petal downword for stage 5. Temperature anr related humidity was recorded by HOBO® H8 Pro Series logger for every half hour.

RESULTS AND DISCUSSION

1. Flowering behaviours

According to three years investigation (Table 1), all of the cultivars flowering from December to April were divided into early, middle, and late flowering groups. The flowering period of 'CAES 4', which is the earliest flowering cultivar, begins at early December and ends at late March. 'CAES 3' is later than 'CAES 4', which blooms from mid-December to early April. '79-6-5-3', 'Halemana' and 'CAES 1', which belong to the middle flowering group, bloom from late January to mid-March, late

Table 1. Flowering period and full-bloomed period of 9 avocado cultivars for three years

Cultivar (Flowering type)	Years	Flowering period		Full bloom		% of vegetative bud
		Date (month/date)	Weeks for flowering	Date [z] (month/date)	Weeks for full bloom	
'CASE 1'	Fiest year	2/16°–4/11	10	2/29°–4/11	8	0
(B)	Second year	1/31°–3/23	10	2/09°–3/23	8	0
	Third year	1/14°–3/11	10	3/11°–3/25	2	14.3
'CASE 2'	Fiest year	3/14°–4/11	6	3/14°–4/11	6	0
(B)	Second year	2/09°–4/20	12	3/23°–4/06	4	20
	Third year	2/25°–4/8	8	3/11°–3/25	4	60
'CASE 3'	Fiest year	2/16°–4/11	10	2/16°–3/28	8	0
(A)	Second year	12/29°–3/23	14	1/31°–3/09	8	0
	Third year	12/05°–3/25	18	1/29°–3/11	8	25
'CASE 4'	Fiest year	2/16°–3/28	8	2/16°–3/14	6	0
(A)	Second year	12/29°–3/09	12	1/31°–3/09	8	0
	Third year	12/05°–3/11	16	1/14°–3/11	10	0
'Halemana'	Fiest year	3/14°–3/28	4	3/14°–3/28	4	0
(A)	Second year	1/31°–3/23	10	2/23°–3/23	6	0
	Third year	2/15°–3/25	8	3/11°–3/25	2	20
'Hall'	Fiest year	2/29°–4/11	8	3/14°–4/11	6	0
(B)		Second year Without reproductive growth				100
	Third year	2/25°–5/07	12	3/11°–3/25	4	0
'Choquette'	Fiest year	3/14°–4/11	6	3/14°–4/11	6	0
(A)	Second year	3/09°–4/20	8	3/23°–4/6	4	0
	Third year	2/25°–5/07	12	-	0	57.1
'Hung-Shin	Fiest year	3/14°–4/11	6	3/28°–4/11	4	0
-Shi-Yeh'	Second year	2/23°–4/20	10	3/9-3/23, 4/20	6	0
(A)		Third year Without reproductive growth				100
'79-6-5-3'	Fiest year	2/16°–3/28	8	2/29°–3/28	6	0
(A)	Second year	1/31°–3/09	8	2/09°–3/09	6	0
	Third year	1/29°–3/11	8	1/29°–3/11	8	0

[z] 'Full blossom' defined as more than 30% flower bud were flowering.

Table 2. Pollination combination of Taiwan main avocado cultivar.

Flowering season	A type		B type	
	Cultivar	Flowering period	Cultivar	Flowering period
Early	'CSAE 3'	Early Dec. to late March	'CSAE 1'	Mid. Jan. to early April
	'CSAE 4'	Early Dec. to mid. March		
Middle	'79-6-5-3'	Late Jan. to late March	'CSAE 1'	Mid. Jan. to early April
	'Halemana'	Late Jan. to late March		
Late	'Hung-Shin-Shi-Yeh'	Late Feb. to mid. April	'CSAE 2'	Early Feb. to mid. April
	'Choquette'	Late Feb. to early May	'Hall'	Late Feb. to early May

January to early April, and early February to late March respectively. The flowering periods of the late flowering cultivars, which include 'Hall', 'CAES 2', 'Hung-Shin-Shi-Yeh' and 'Choquette', are from late February to mid-April, early March to early April, early March to early April, and early March to mid-April respectively. The full bloom period of nine cultivars lasts about 1 to 2 month. 'Hall' and 'Hung-Shin-Shi-Yeh' were the seciours biennual bearing cultivars, due to their biennual flowering character. 'CASE 2' and 'Choquette' had slightly biennual bearing character, about 60% bud would be vegetative bud in off year. Following to the flowering date and flowering type, nine Taiwan avcado cultivars could divide into three pollination combination (Table 2). Groupe one, the early flowering groupe, were 'CASE 4' (A type,), 'CASE 3' (A type) and 'CASE 1' (B type). Groupe two, the middle flowering groupe, were '79-6-5-3' (A type), 'Halemana' (A type) and 'CASE 1' (B type). Groupe three, the late flowering groupe, were 'Hung-Shin-Shi-Yeh' (A type), 'Choquette' (A type), 'Hall' (B type) and 'CAES 2' (B type).

2.Effect of the low temperature on flowering cycle

Taiwan didn't have good early flowering B type avocado cultivar, but most of the early flowering A type cultivars set well and no biennial bearing.

Table 3. Relationships between flowering cycle and temperature for 'CAES 3' avocado (A type).

Date	Marked Number[z]	Flower State[y]	Temp( )[x]		O'clock										
			Max.	Min.	8	9	10	11	12	13	14	15	16	17	18
2/1/01	20a	Female	28.3	12.9						20	20	20	20		
2/2/01	20a		14.7	13.1											
2/3/01	20a	Male	25.2	13.6	16	20	20	20*	06	01	01				
2/2/01	21b	Female	14.7	13.1										21	21
2/3/01	21b	Female	25.2	13.6	21	21	21	21	19	15	13	09			
2/4/01	21b	Male	27.4	15.8					12	21*	21	21	21	21	18
2/5/01	25c	Female	28.8	15.2				25	25	25	14				
2/6/01	25c	Male	29.8	17.3						25*	25	25	25	25	12
2/6/01	39d	Female	29.8	17.3				39	39	39	29				
2/7/01	39d	Male	26.2	15.7						39	39*	39	39	39	39
2/7/01	50e	Female	26.2	15.7				50	50	50	50	26	02		
2/8/01	50e	Male	24.3	14.0								49	50*	50	50
2/9/01	50e	Male	25.2	14.4	50	44	03								
2/8/01	50f	Female	24.3	14.0					50	50	50	50	50	36	22
2/9/01	50f	Male	25.2	14.4							50	50	50*	50	50
2/23/01	36g	Female	33.0	17.7				36	36	36	36	03			
2/24/01	36g	Male	30.3	16.2					36	36*	36	36	36	36	36
2/24/01	40h	Female	30.3	16.2			40	40	40	40					
2/25/01	40h	Male	23.7	12.0							13	40	40	40*	40
2/25/01	40i	Female	23.7	12.0						40	40	40	40	40	40
4/6/01	36j	Female	25.3	18.1		36	36	36	36	36	18				
4/7/01	36j	Male	29.2	20.2					36	36	36*	36	36	28	15
4/7/01	26k	Female	29.2	20.2		26	26	26	26	25					
4/8/01	26k	Male	28.5	19.3				05	26	26	26*	26	26	08	06
4/8/01	40l	Female	28.5	19.3		40	40	40	40	35	06				

[z] Arabic numerals showed the number of flower marked, and letter beside was used to distinguish different flowering cycle.

[y] 'Female' means female stage, 'Male' means male stage, asterisk means anther adhesive.

[x] 'Max' indicates the maximum temperature of that day, and 'Min' indicates the minimum temperature of last night.

In southern Taiwan, frequency of low temperature cause by winter monson (cold current) are very high, most of the time there will lower than 15°C sometimes the temperature will lower than 5°C. Although we investigate the flowering cycle of 4 main avocado cultivars, but the responses of two early flowering cultivar were almost the same, so we showed the result of 'CASE 3' (Table 3) only. Flowering cycle will changes slightly when night temperature lower than 18°C, and significantly changes when temperature lower than 15°C, especially after low day temperature in 'CASE 3'. In some cases not only male stage but also female stage were prolong over night. Low temperature also delay cause the dehiscent of the anther. This resulted in one to three hours overlape of male and female stage of early flowering A type avocado cultivars in Taiwan. According, Lu's (2002) observation, 'CASE 1', the middle flowering B type avocado, would lost it female stage during long cold weather. The flowering cycle of late lowering B type cultivars, such as 'Hall' (Table 4), would changes too, although the climate will getting constant.

Table 4. Relationships between flowering cycle and temperature for 'Hall' avocado (B type).

Date	Marked Number[z]	Flower State[y]	Temp( )[x]		O'clock										
			Max.	Min.	8	9	10	11	12	13	14	15	16	17	18
3/11/02	39a	Female	28.0	13.9								39	39	39	39
3/12/02	39a	Male	30.2	13.6	37	39	39	39*	39	39	39	38	37	31	25
3/12/02	40b	Female	30.2	13.6								40	40	40	40
3/13/02	40b	Male	30.6	14.8	40	40	40	40*	40	40	40	38	24	12	8
3/13/02	40c	Female	30.6	14.8							30	40	40	40	38
3/25/02	25d	Female	27.6	19.0								25	25	25	24
3/26/02	25d	Male	30.0	18.8	25	25	25*	25	25	13	1				
3/26/02	34e	Female	30.0	18.8							34	34	34	23	8
3/27/02	34e	Male	32.1	20.2	33	33*	33	33	14	2	1	1	1	1	1
3/27/02	24f	Female	32.1	20.2							24	24	21	12	3

[z] ,[Y] ,[X] :the same as Table 3.

Table 5. Relationships between flowering cycle and temperature for 'Choquette' avocado.

Date	Marked Number[z]	Flower State[y]	Temp( )[x]		O'clock										
			Max.	Min.	8	9	10	11	12	13	14	15	16	17	18
3/11/02	40a	Female	28.0	13.9			40	40	40	40	20	17	8		
3/12/02	40a	Male	30.2	13.6					19	40	40*	40	40	40	40
3/12/02	39b	Female	30.2	13.6			39	39	39	37	20	8	2		
3/13/02	39b	Male	30.6	14.8					29	39*	39	39	39	39	33
3/13/02	40c	Female	30.6	14.8		40	40	40	40	16					
3/25/02	40d	Female	27.6	19.0		40	40	40	40	40	32	2			
3/26/02	40d	Male	30.0	18.8					39	40	40*	40	40	40	40
3/26/02	38e	Female	30.0	18.8		40	40	40	40	32	10	2			
3/27/02	38e	Male	32.1	20.2				25	40	40*	40	40	40	40	40
3/27/02	40f	Female	32.1	20.2	40	40	40	40	38	12	11	9	2	2	2

[z] ,[Y] ,[X] :the same as Table 3.

The conspicuously responses of 'Hall' were very long male flower stage and overlape of wale and female stage. But, in A type cultivars, such as 'Choquette', the male stage seems was not influence by low temperature, and almost no overlaping of male and female flower (Table 5). While the related humity in Taiwan during flowering was always high, so there had a part of stigma still under aceptable condition (Table 6), even in male close stage. So, Taiwan avocado sould had very high colse or self pollination ability.

Table 6. White stigma percentage of 'CAES 3' and 'CAES 4' avocado at male flower stage(%)

Date	CAES 3		CAES 4	
	Male opening	Male closing	Male opening	Male closing
2/4/01	61.9	42.9	57.1	42.9
2/6/01	44.0	20.0	06.5	0.0
2/7/01	15.4	10.3	0.0	0.0
2/8/01	64.0	–	52.0	–
2/9/01	56.0	48.0	54.0	–
2/24/01	0.0	0.0	0.0	–
2/25/01	42.5	–	10.3	–
4/7/01	48.6	47.1		
4/8/01	46.2	42.3		

CONCLUSIONS

Taiwan avocado cultivars can devided into three groupe, according to flowering date. Although the early flowering groupe didn't had good B type cultivar, but still set well. High frequency of low temperature during avocado flowering season, especially or early flowering cultivars, might be the most important reason for high setting of early flowering A type cultivars.

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